Workshop Without Walls: Upstairs Downstairs

Breakout Group 3 Note-taking

Debate #2: Does composition matter?

What is important to know about composition, and what do we need to observe or model in order to interpret data we can actually get from exoplanets?

Is there a better way to frame the question, **how useful is the composition**? What useful predictions can we make, based on what we can measure.

- Difficult to measure absolute abundances in stars, but ratio plots are much better à same stellar model/atmosphere, Mg/Si ratio might be better constrained than either one element alone
- If we are restricted by what we can measure, even with perfect information we might be limited. Not straightforward, deterministic outcome.

Come up with questions that we can try to robustly answer.
We have to impose stronger model assumptions about exoplanets than the data might empirically give us.

Looking for trends in iron **abundance vs. orbital period** would be possible for larger number of planets -- can we test assumption that planets follow compositional trends of the host star?

How different are moon and mercury in terms of rock to metal ratio?
mercury - 50/50
moon - 80/20

(Do we agree with statement that Earth is on rock to ice continuum?)
volatile budgets, water to rock ratios, Al 26 (short lived radionuclide for providing heating)
→ guess abundance in planet based on host star?
are these systems more likely to be filled with dry objects (formed in high Al 26 environment)
*Are there other traces for r-process supernova that would be a proxy for Al 26?
Europium as another r-process element does that scale in any significant way to Al 26?

In abiotic world, more nitrogen would be in the atmosphere. biology fixes nitrogen into sediment, subducted down into mantle.
*Important for biosignatures → having background gas like nitrogen helps Earth keep its oxygen
*How much more nitrogen is partitioned in the atmosphere on an abiotic world?
*Can we observe nitrogen in an atmosphere
→ pressure broadening (collision induced absorption), fairly prominent line in spectrum
→ with high enough spectral resolution, or indirectly by Rayleigh scattering

How to constrain models of planetary interior? Can we get moment of inertia information from planet interacting with host star?

How do we get the redox state of a planet's mantle from the stellar spectrum?

Fe/O mechanism for oxidizing Earth's mantle doesn't work → to get iron segregate out, you need iron droplets to interconnect, ratio of iron forms pockets. problem of core formation.
*Not necessarily observable on exoplanets, but can be studied more in labs on Earth

If given compositional information, how much can we say about mantle oxygen fugacity?

How much of Earth's water is in the mantle? → uncertain, but estimates of ~2 oceans
→ how do we constrain that? experiments with minerals we know that retain water
→ what determines the partitioning of water between the surface and the mantle? would that be similar on another planet?

Could we identify water world from density measurements?
→ challenging because water is intermediate density between rock, hydrogen and helium, so bulk density estimates could come up with averages that look like water
→ find a planet that is sufficiently low density that require volatile envelope, but is close enough to its star that hydrogen atmosphere would be unlikely (due to escape)

Can we observe hydrogen escape during a planet's runaway phase?
How long does it take?
→hydrogen corona around planet that would scatter in lyman alpha, but could we resolve from the star? works for gas giants, but can we do that for smaller planets?

Rocky/non-rocky transitions in other planetary forming regions?